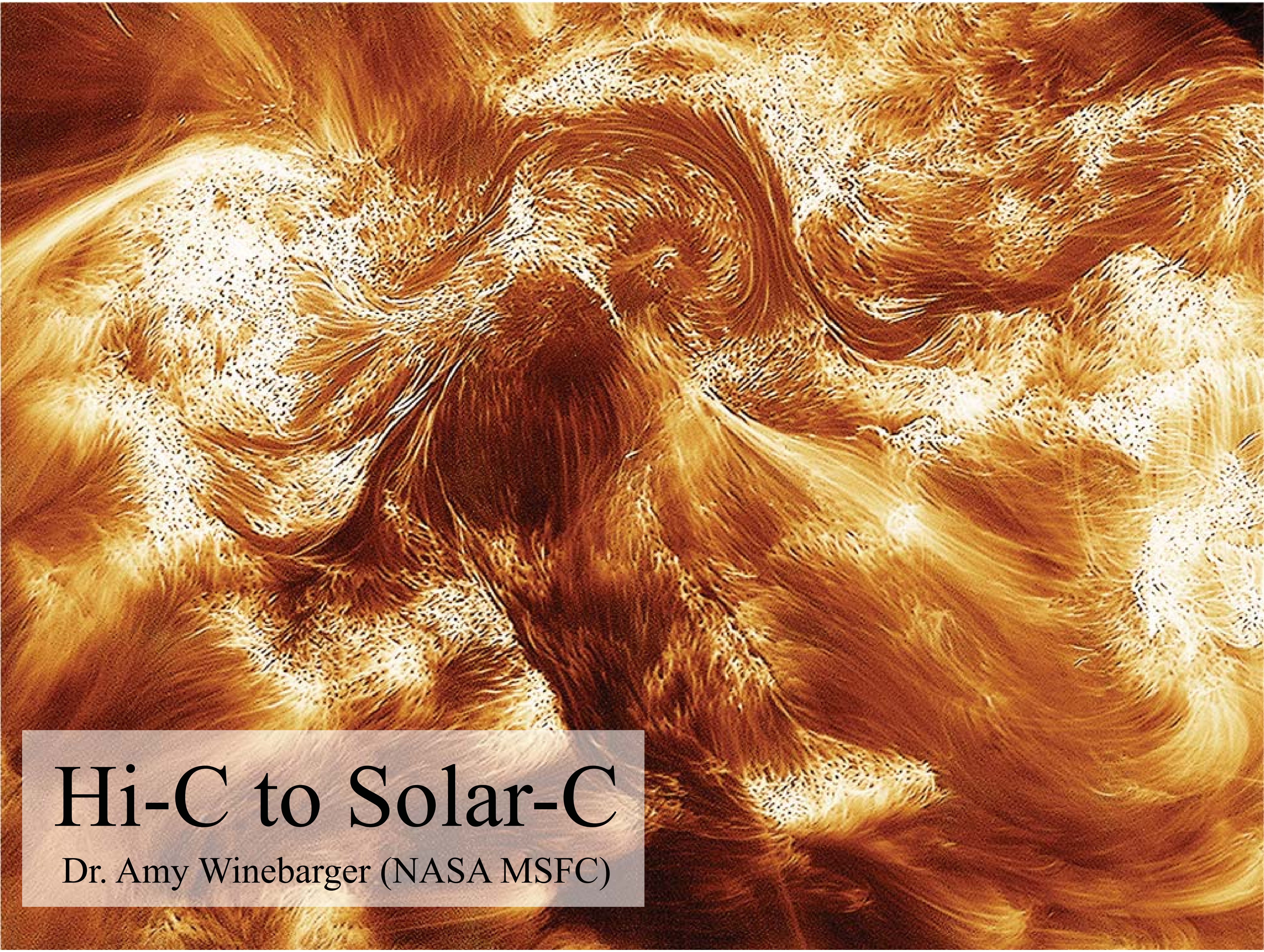
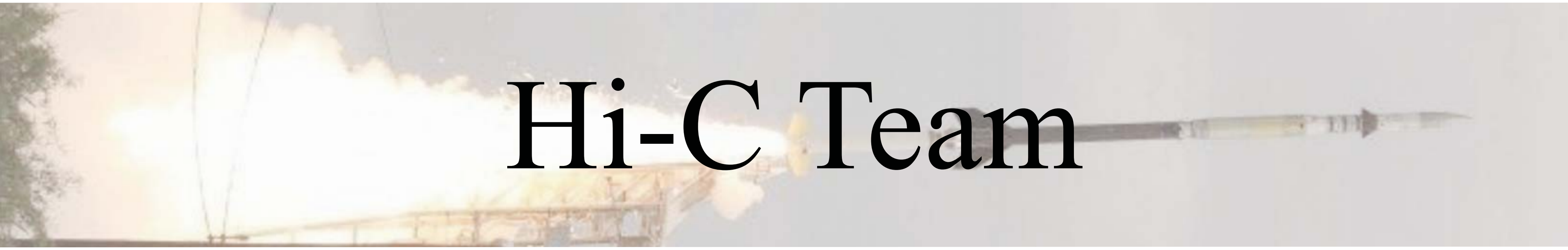


Hi-C to Solar-C

Dr. Amy Winebarger (NASA MSFC)



Hi-C Team

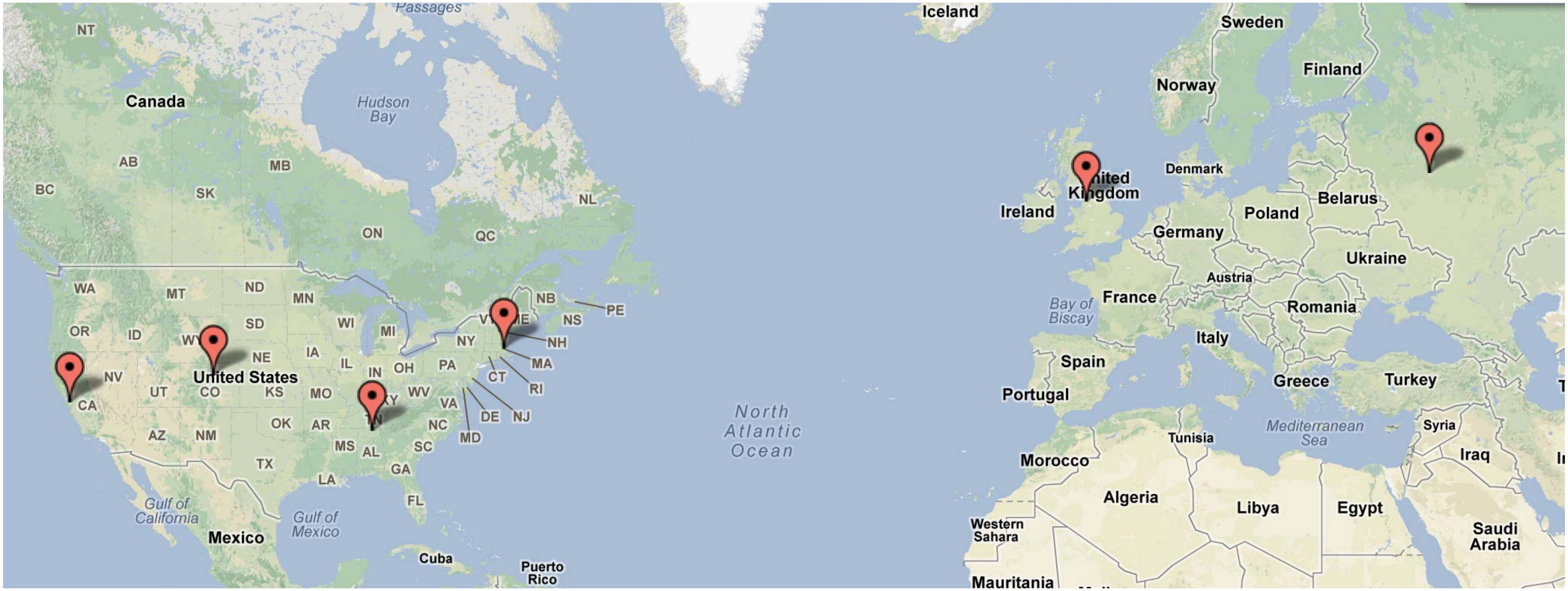
Image above shows Hi-C launch team standing in front of the Hi-C rocket on the at White Sands Missile Range.

Jonathan Cirtain, PI (MSFC)

Science Team:
Leon Golub (SAO)
Ken Kobayashi (UAH)
Kelly Korreck (SAO)
Robert Walsh (UCLAN)
Amy Winebarger (MSFC)
Bart DePontieu (LMSAL)
Craig Deforest (SWRI)
Sergey Kuzin (LI)
Alan Title (LMSAL)
Mark Weber (SAO)

Engineering Team:
Peter Cheimets (SAO)
Dyana Beabout (MSFC)
Brent Beabout (MSFC)
William Podgorski (SAO)
Ken McKracken (SAO)
Mark Ordway (SAO)
David Caldwell (SAO)
Henry Berger (SAO)
Richard Gates (SAO)
Simon Platt (UCLAN)
Nick Mitchell (UCLAN)

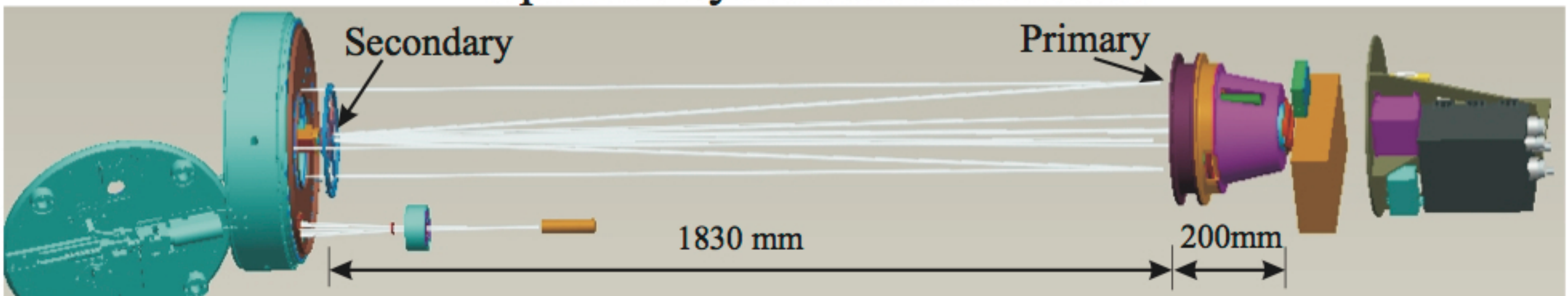
Partner Institutions



NASA Marshall Space Flight Center (MSFC)
University of Alabama – Huntsville (UAH)
Smithsonian Astrophysical Observatory (SAO)
University of Central Lancashire, UK (UCLAN)
Lockheed Martin Solar and Astrophysical Laboratory (LMSAL)
Southwest Research Institute (SWRI)
Lebedev Institute (LI)

High-Resolution Coronal Imager

Optical Layout with Tolerances



Primary to secondary requirements: Distance: +/- 0.05mm
Tilt: 36″
De-center: 0.05mm

Focal Plane: Axial Position: +/- 1mm

Hi-C is a narrowband EUV imager. The wavelength band is center at 193 Å.

Hi-C Telescope Optical Design

Telescope Properties:		**Primary Mirror:**	
Focal Length	23.9 m	Radius of Curvature	4000±4.0 mm
Plate Scale	114 μm/arcsec	Diameter	240 mm
Focal Ratio	f/109	RMS slope error	0.4 μrad
Field of View	6.8x6.8 arcmin		
RMS Spot Diameter (averaged over f.o.v.)	0.08 arcsec		
		Secondary Mirror:	
CCD Camera:		Radius of Curvature	370±0.5 mm
		Conic	-1.14±0.10
Size	49.1 mm^2	Diameter	30 mm
Scale	0.1 arcsec/pixel	RMS slope error	0.1 μrad

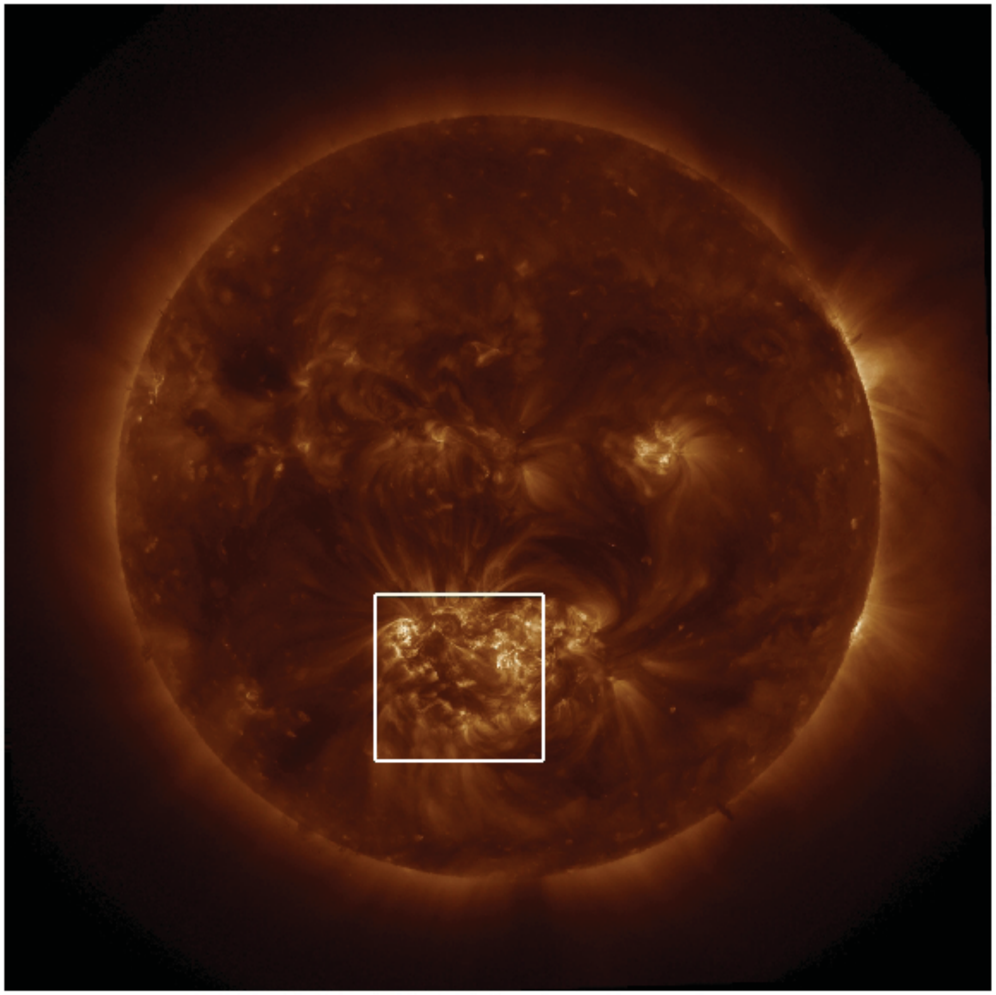
Launch and Recovery

• Hi-C was launched out of White Sands Missile Range on July 11, 2012.
• The instrument obtained ~5 minutes of solar observations.
• The payload was recovered.

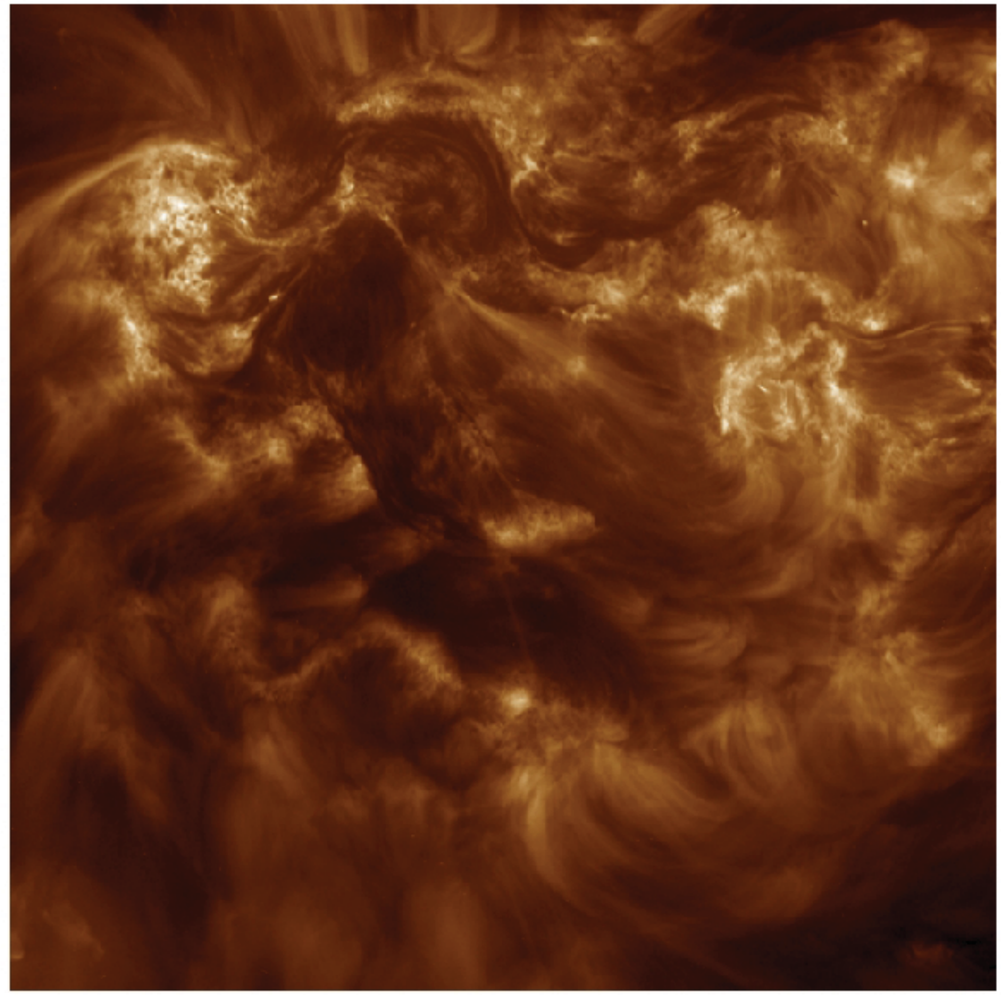
Recovery team

Hi-C Target

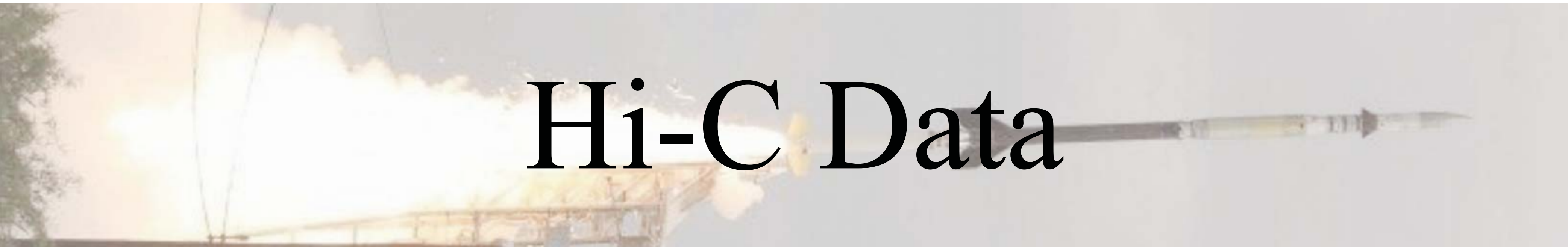
AIA 193–Å 11–Jul–2012 18:55:07



Hi–C Field of View



The Hi-C target was Active Region 11520.



Hi-C Data

Hi-C collected data for 345 s.
Several images was blurred due to rocket jitter and pointing.

Full frame (4k x 4k) data:
- 29 full resolution images
- 2 s exposure, 5.5 s cadence

Partial frame (1k x 1k) data
- 86 full resolution images
- 0.5 s exposure, 1.4 s cadence

Data was released to the solar physics community via Virtual Solar Observatory in January, 2013. It was downloaded ~900 times in the first 6 months.

Hi-C First Results

Spatial Resolution

Braided Loops (Cirtain et al.)
Low-amplitude Transverse Waves (Morton et al.)
Loop Substructure (Peter et al., Brooks et al.)
Bi-directional Flows along a Filament (Alexander et al.)

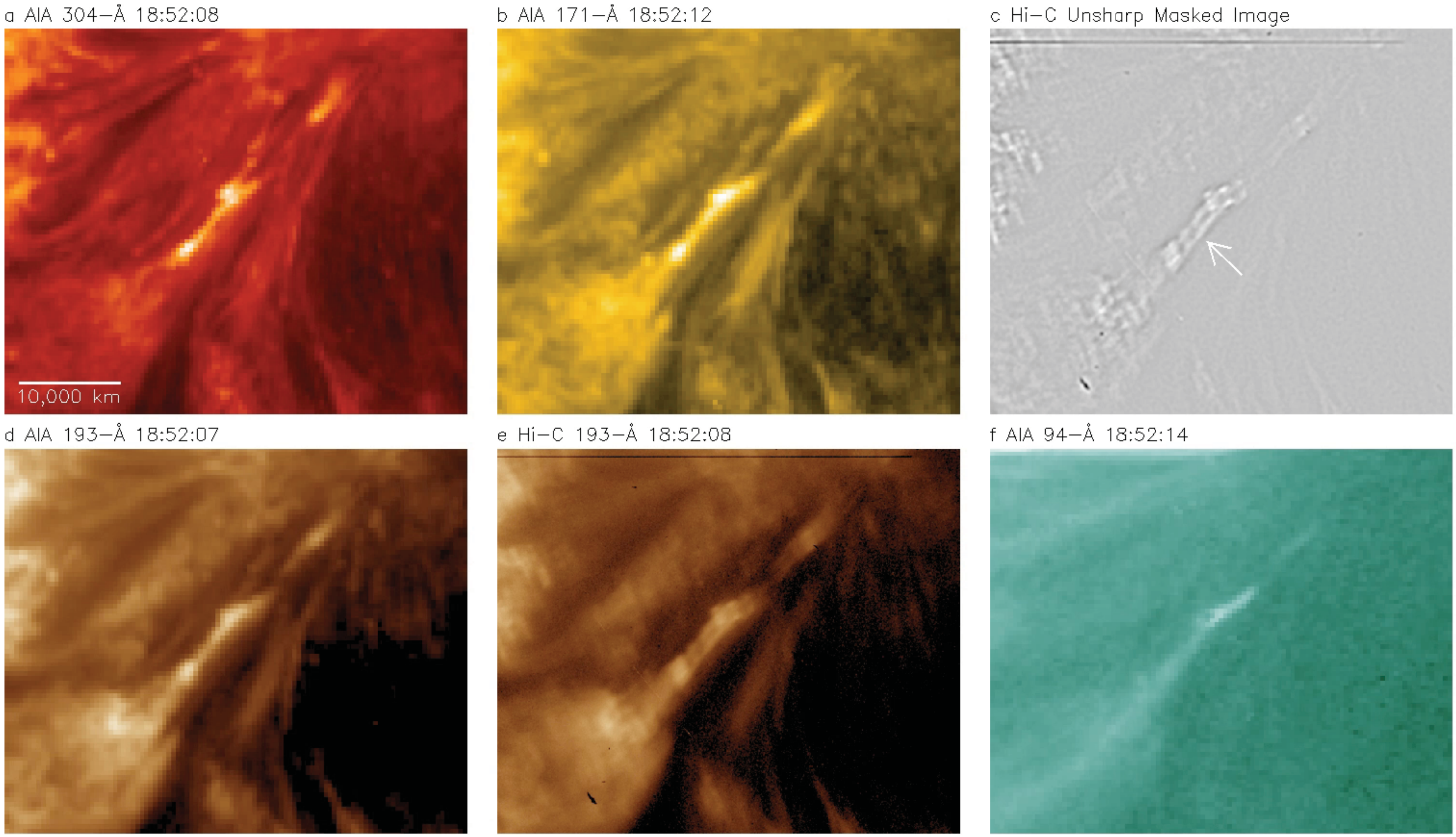
Temporal Resolution

Dynamic events in moss (Testa et al.)
Small-scale Bright "Dots" (Regnier et al.)
Evolving Transition Region Loops (Winebarger et al.)

Required Effective Area

Linear substructure in transient events (Winebarger et al.)

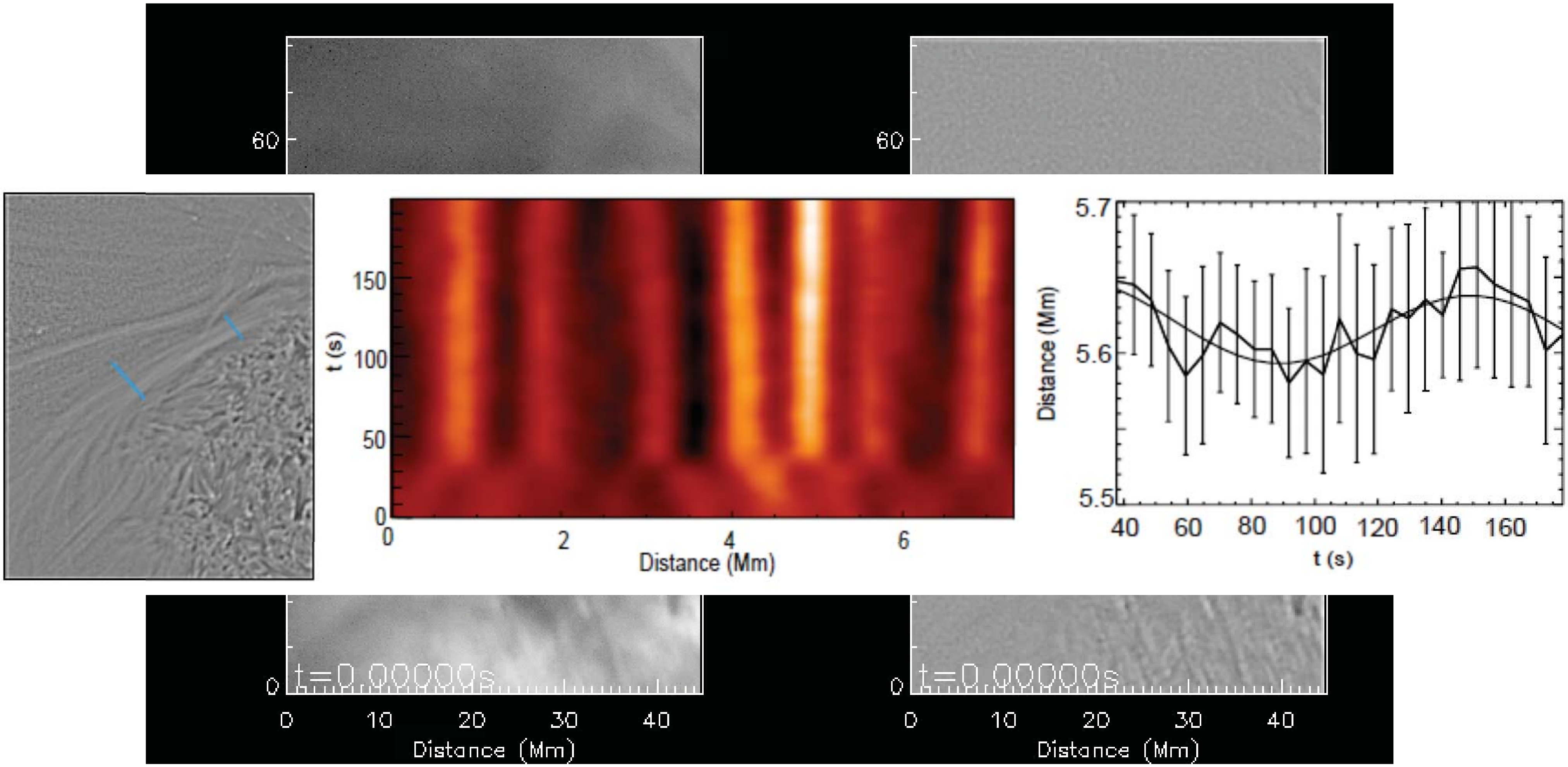
Braided Loops



Hi-C made the first observations of coronal braiding and reconnection.

Cirtain et al., 2013, Nature, 493, 501

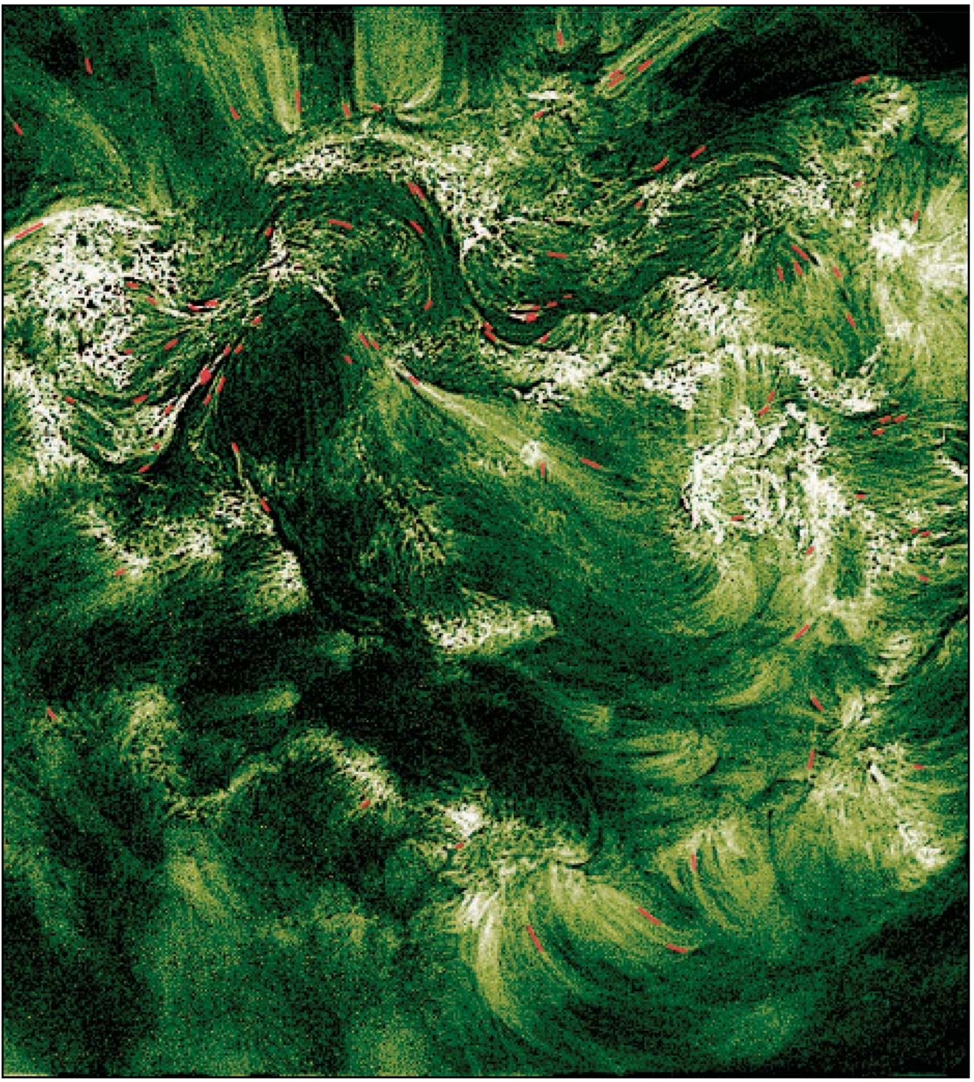
Transverse Waves

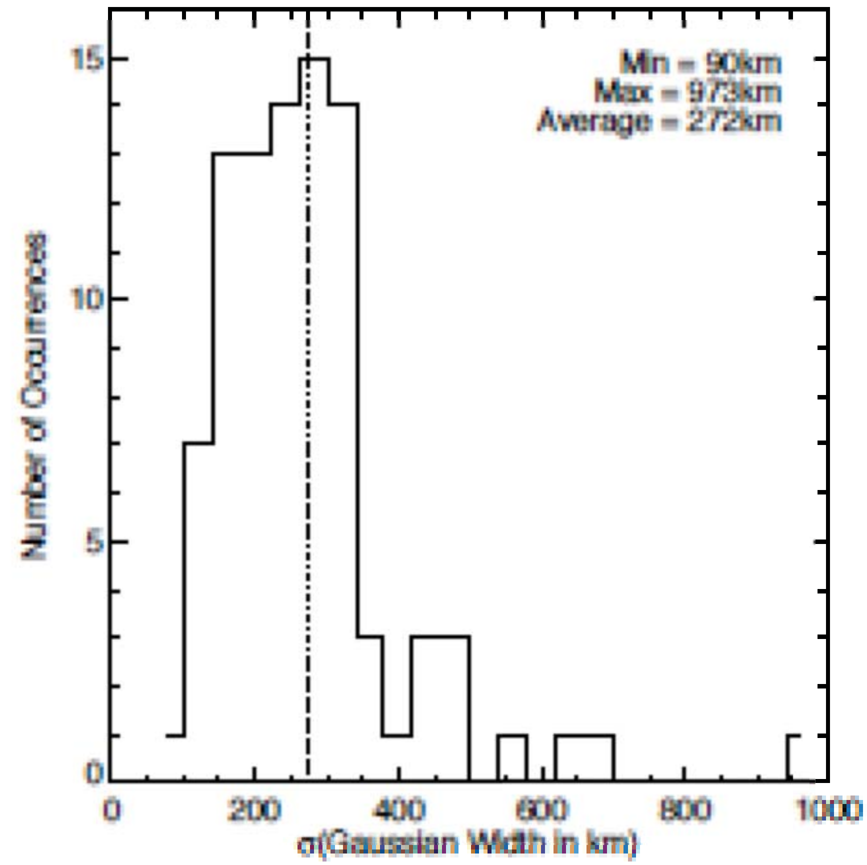


Hi-C observed low-amplitude transverse waves, not observable in AIA.

Morton & McLaughlin, 2013, A&A, 553, L10

Loop Substructure

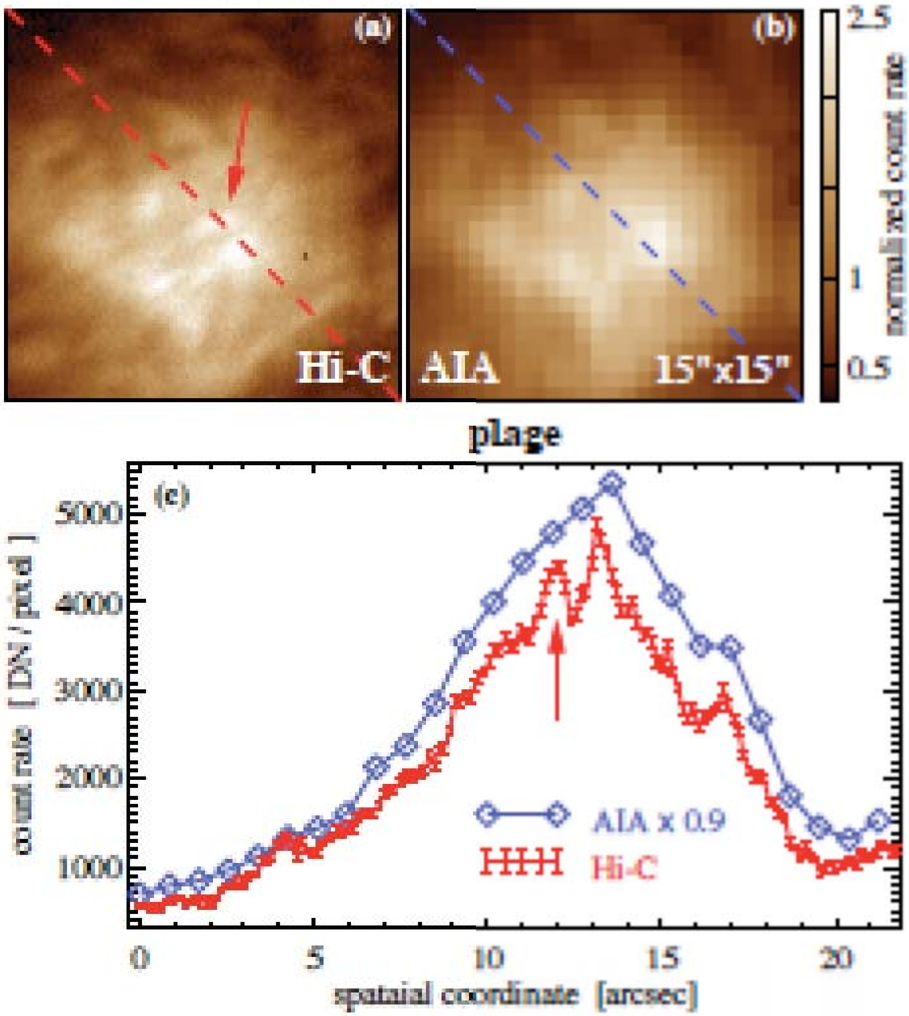


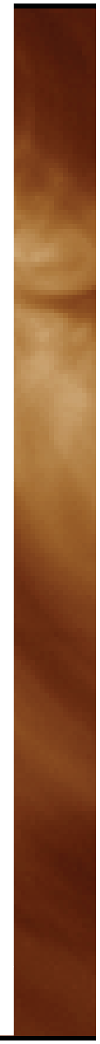


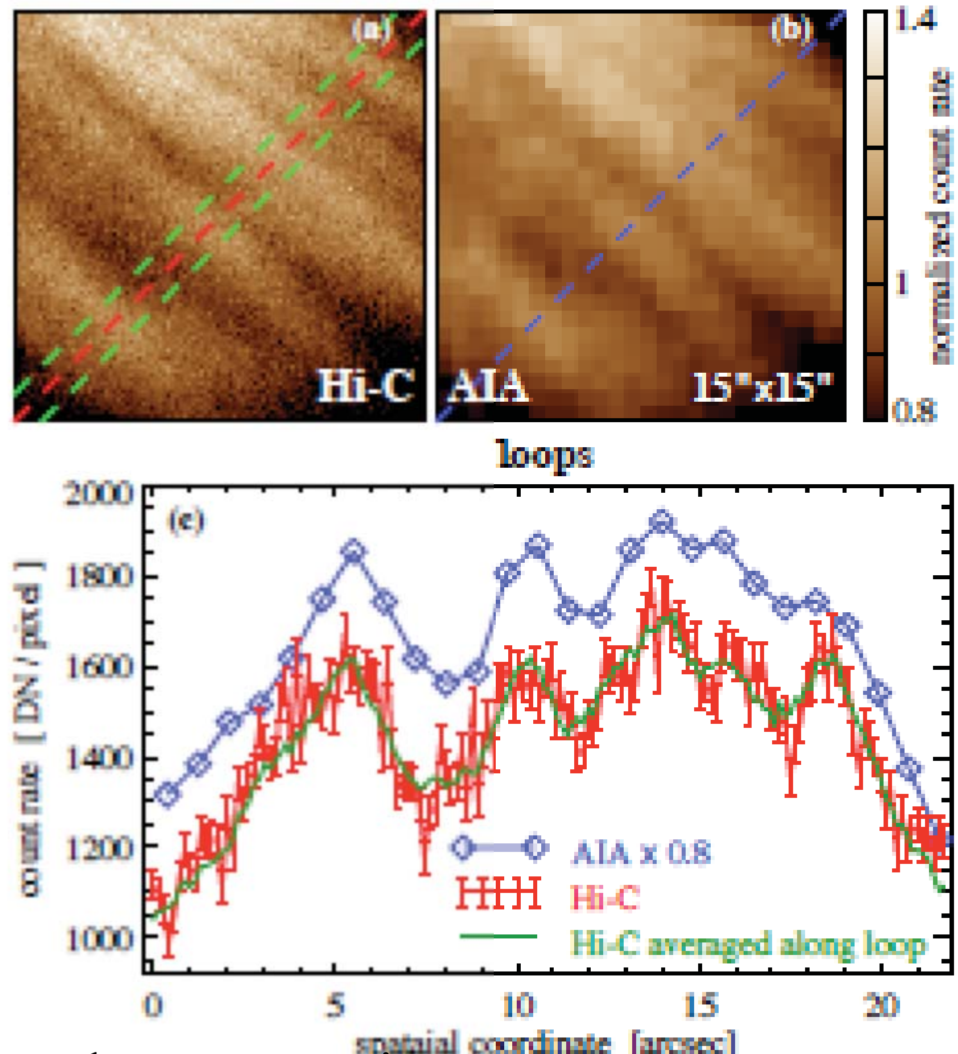
The widths of 91 loop segments were measured.
The most typical width with 270 km.

Brooks et al., 2013, ApJ, 772, 18

Loop Substructure



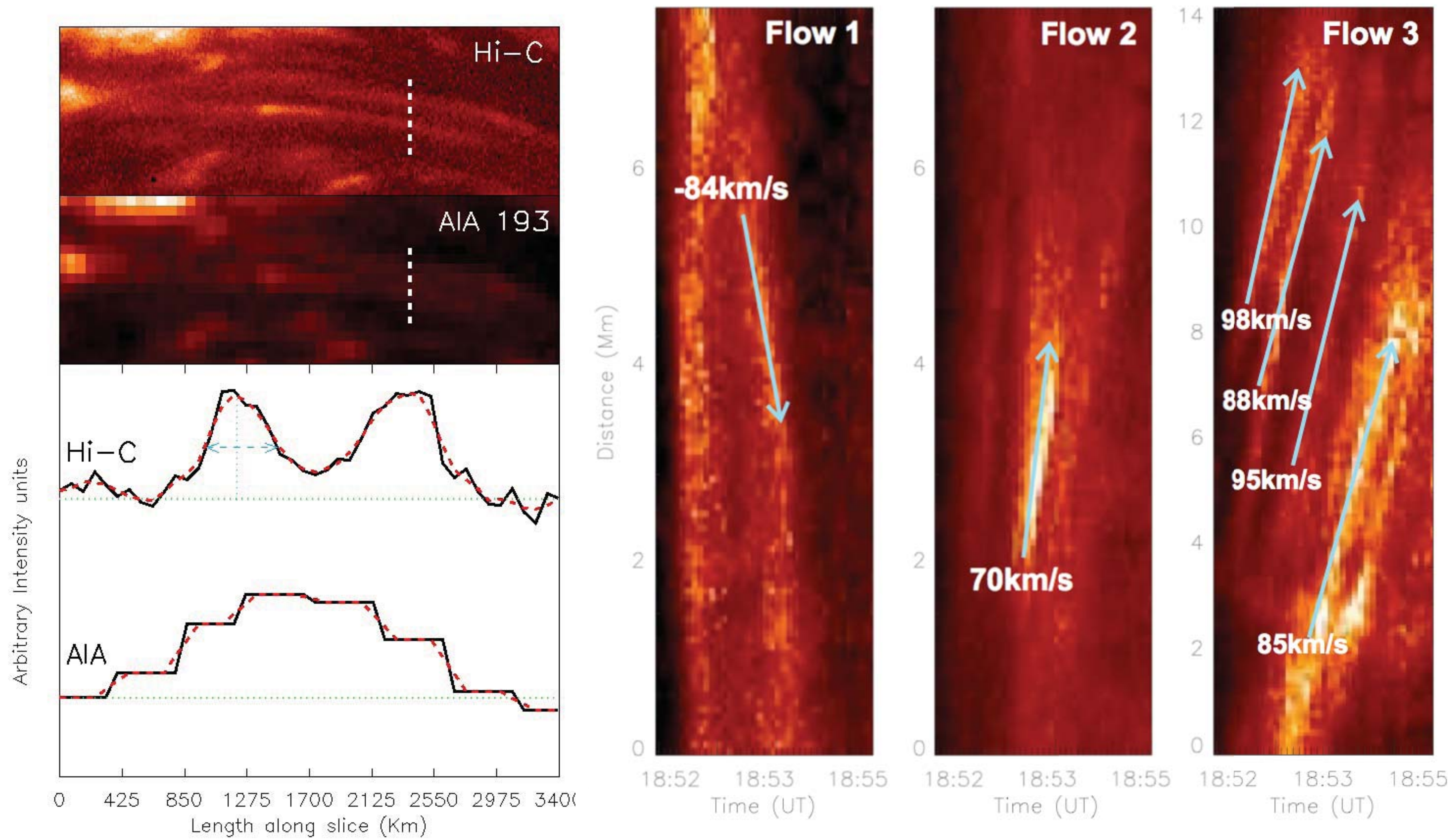




Demonstrated that Hi-C can resolve small-scale structure in the plague, but does not observe it in loops. If loops have substructure, then d < 15 km.

Peter et al., 2013, A&A, 556, 104

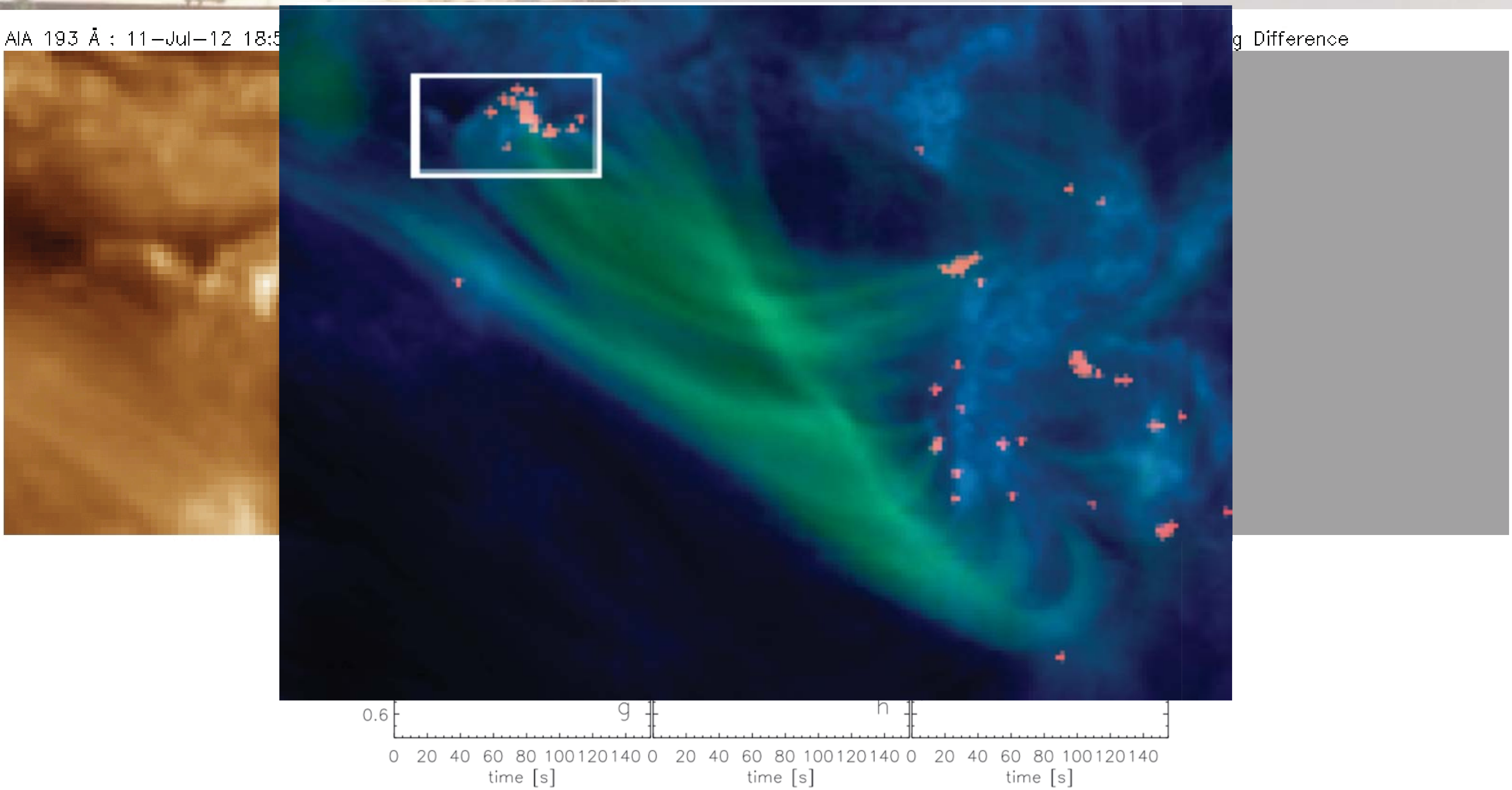
Bi-directional Flows



Discovered bi-directional flows along a filament that was unresolved by AIA. Velocities were > 70 km/s.

Alexander et al., 2013, ApJ, 775, 32

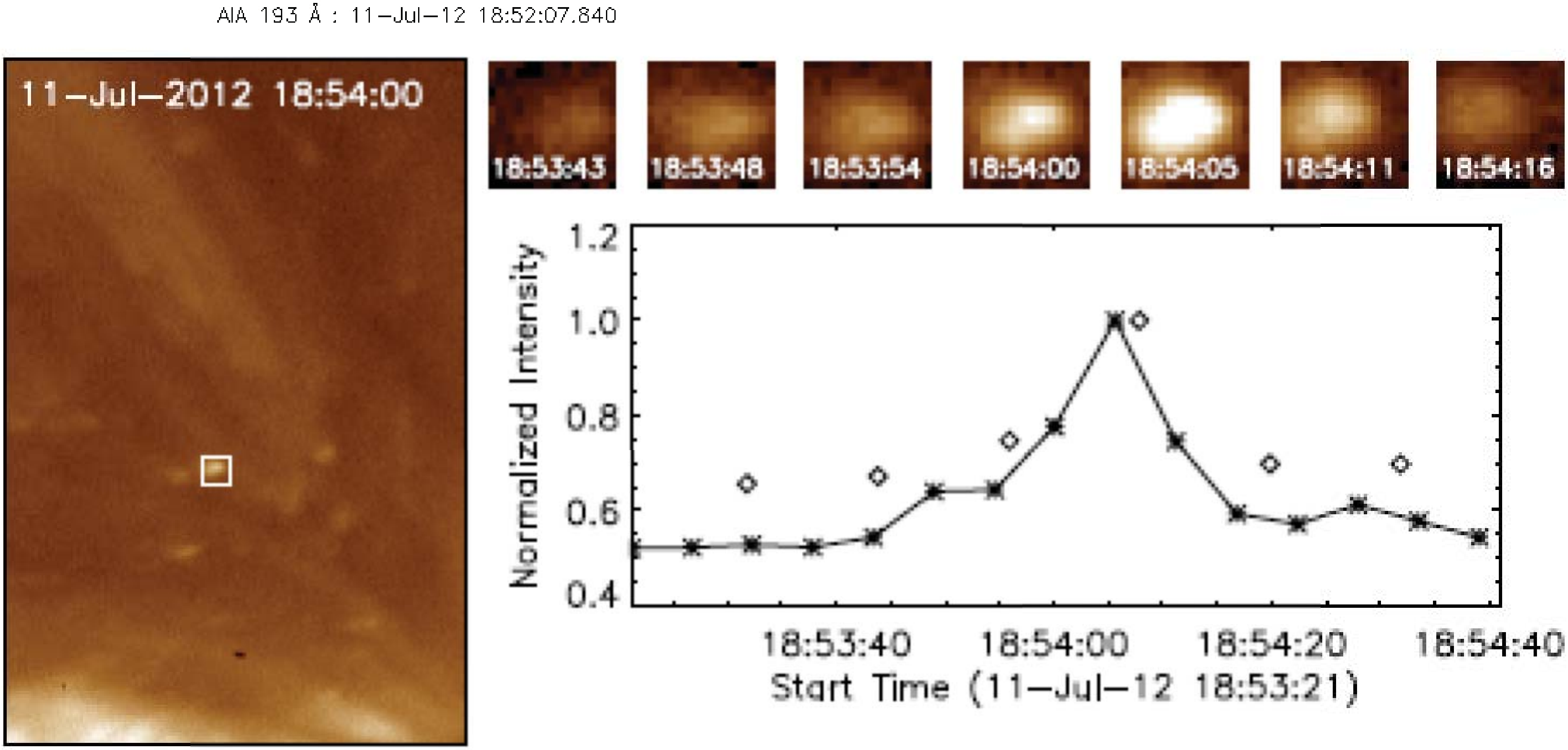
Dynamics in the Moss

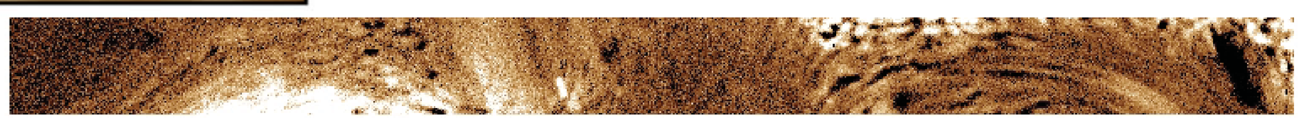


Discovered dynamics in moss at footpoints of crossed high temperature loops. Suggest this was due to coronal reconnection.

Testa et al., 2013, ApJ, 770, 1

Bright “Dots”

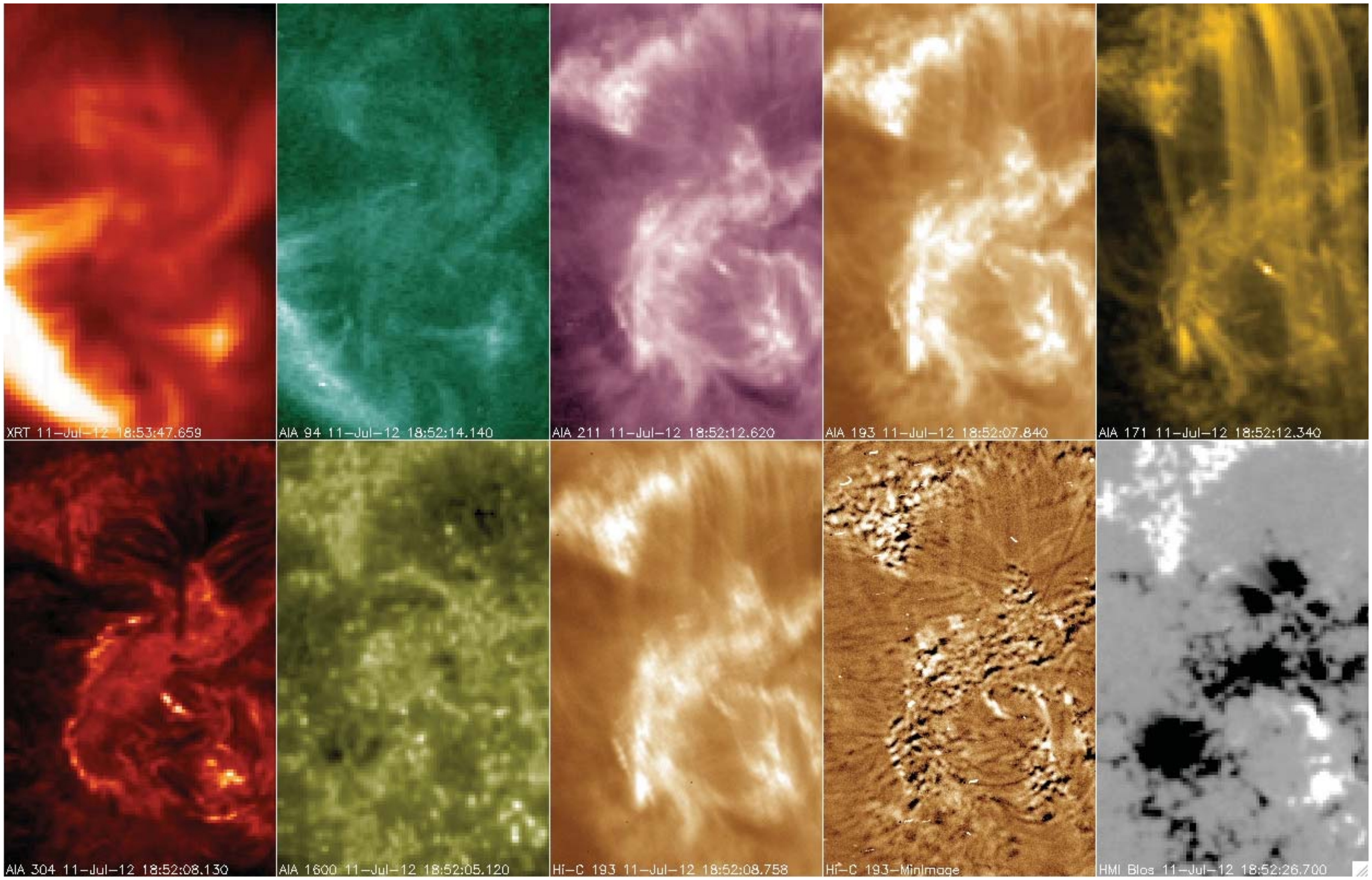




Bright, quickly evolving “dots” were discovered at the northern edge of the Hi-C field of view.

Regnier et al., 2013, ApJ, submitted

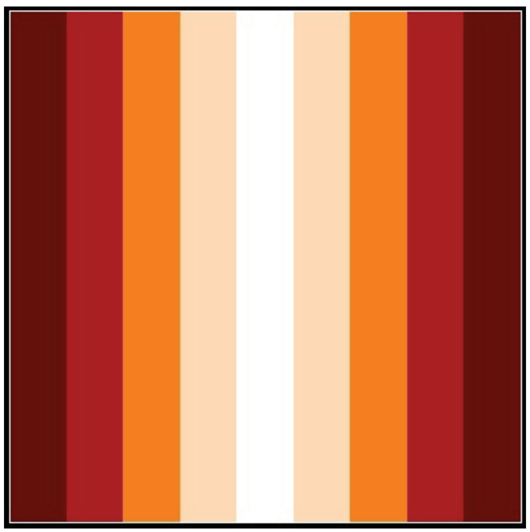
Transition Region Loops

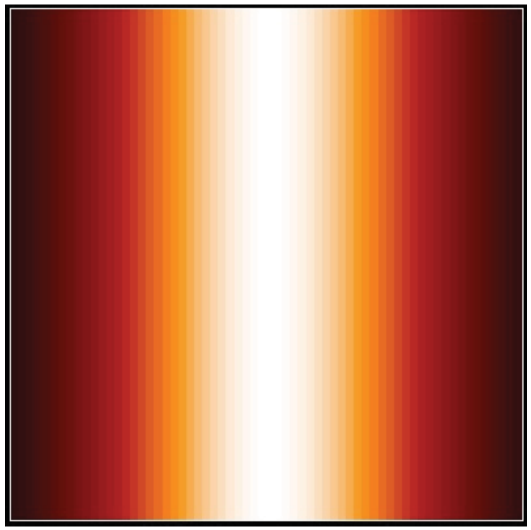


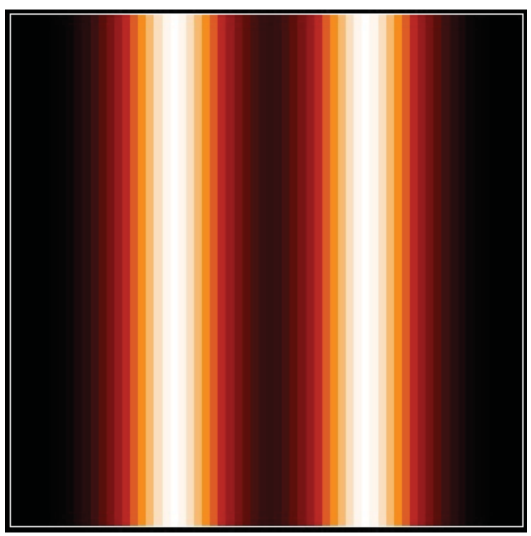
Small-scale, quickly evolving, inter-moss loops were discovered.
The maximum temperature of the loops were found to be ~10^5 K.

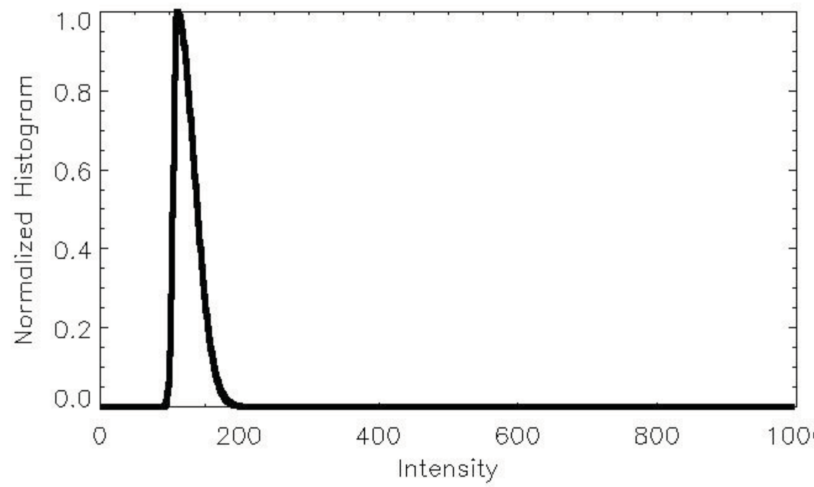
Winebarger et al., 2013, ApJ, 771, 21

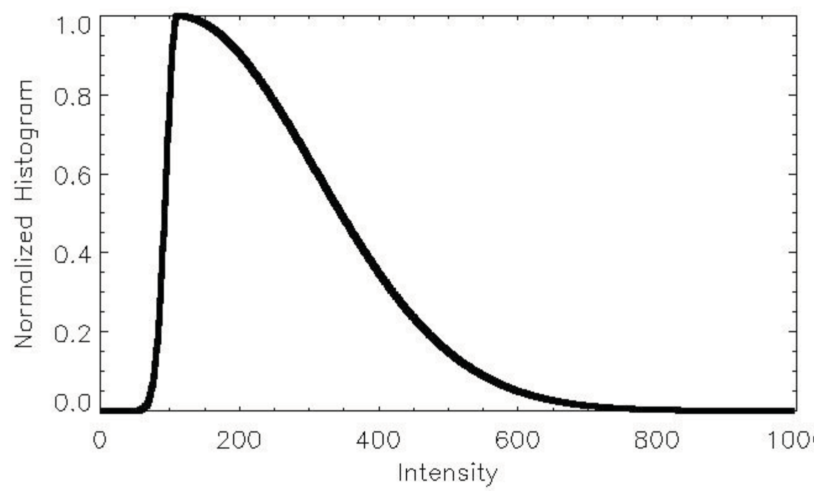
Effective Area Requirements



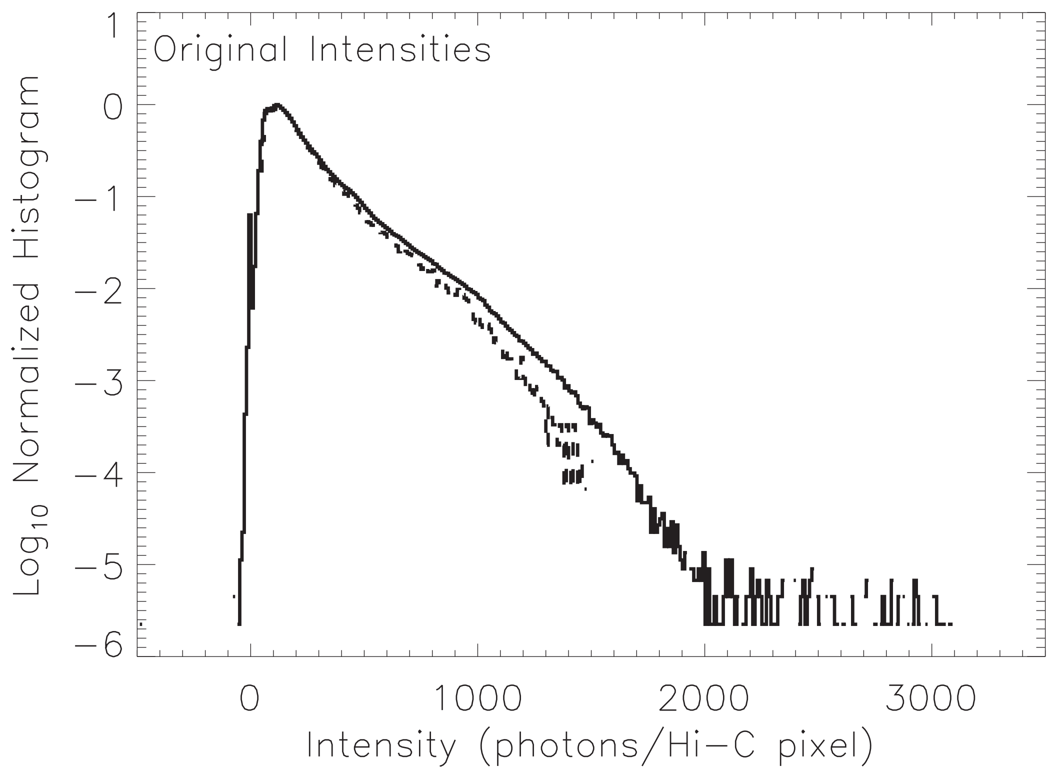








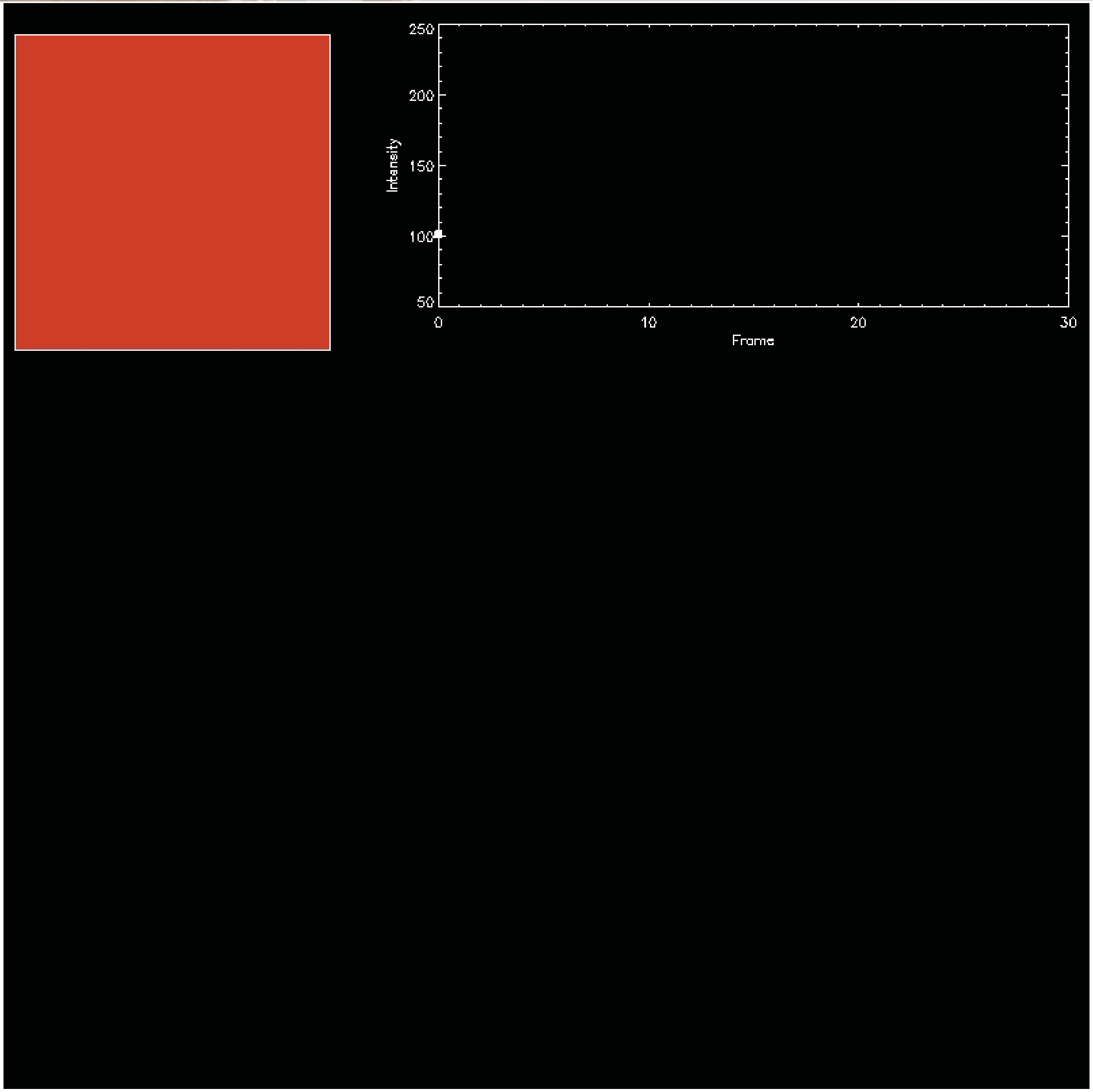
Observed by Hi-C



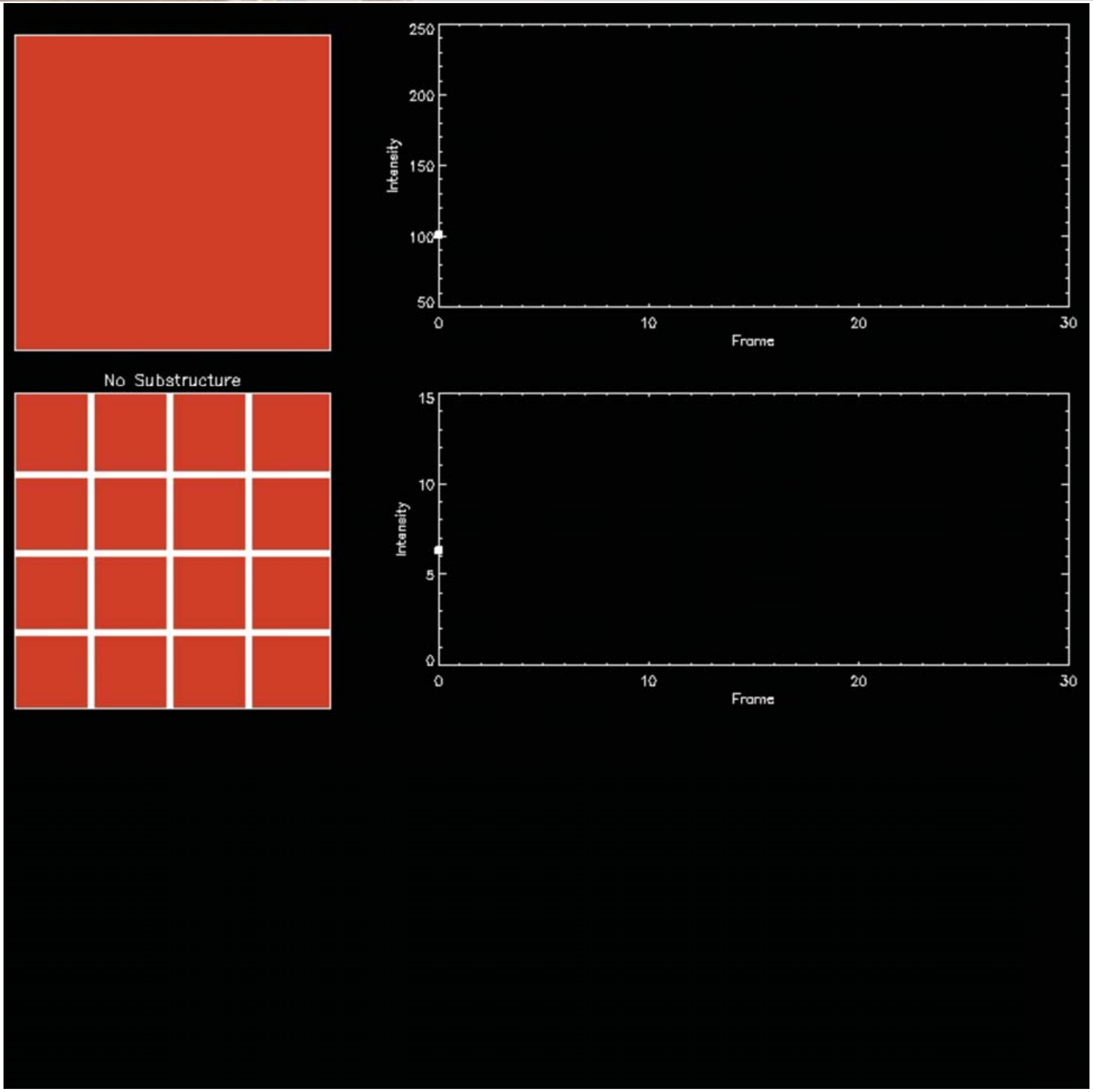
Hi-C initially did not appear to demonstrate the ~3-4 increase in intensity expected for linear substructure.

Winebarger et al., 2013, in prep

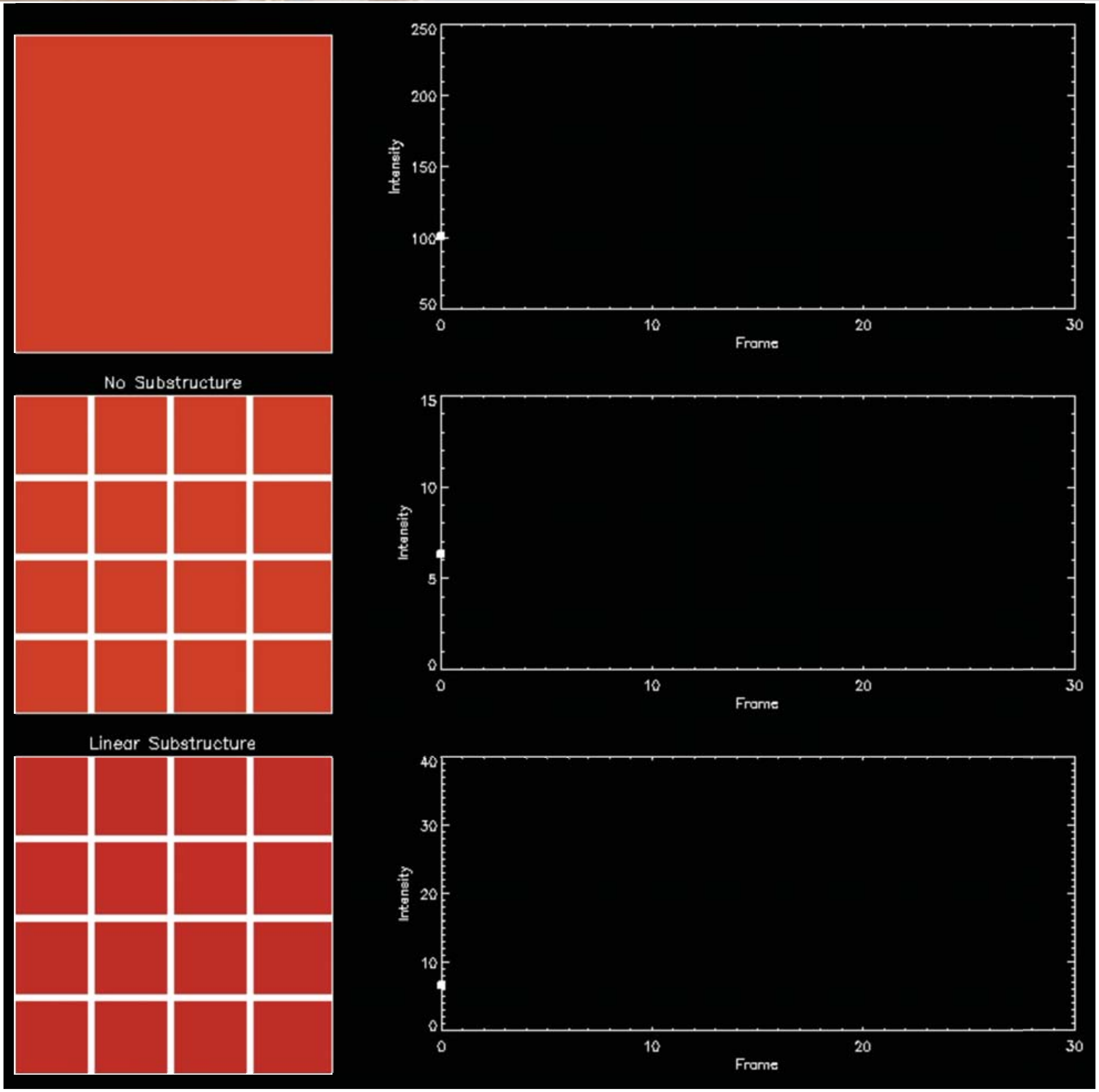
Transient Events



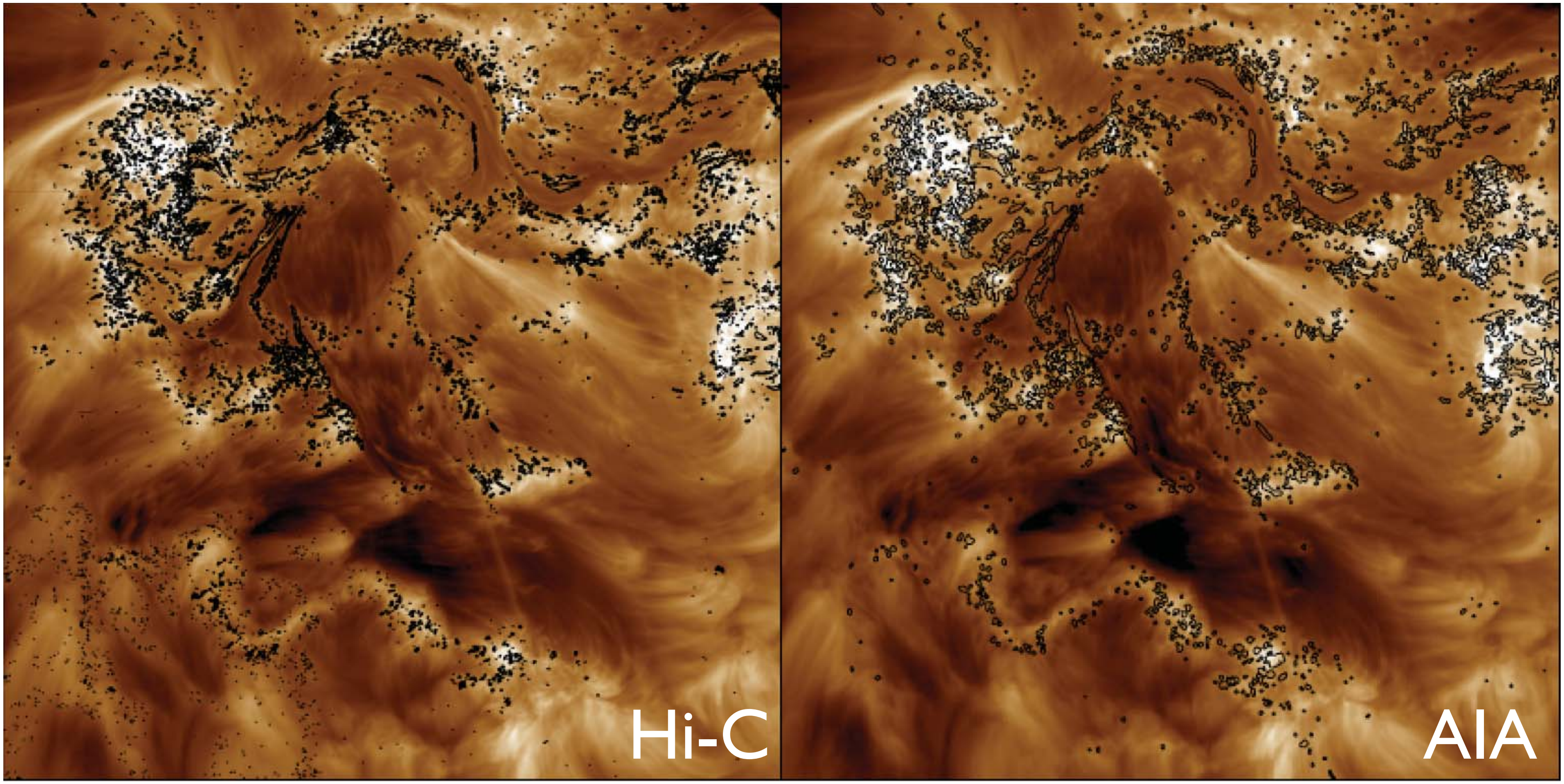
Transient Events



Transient Events

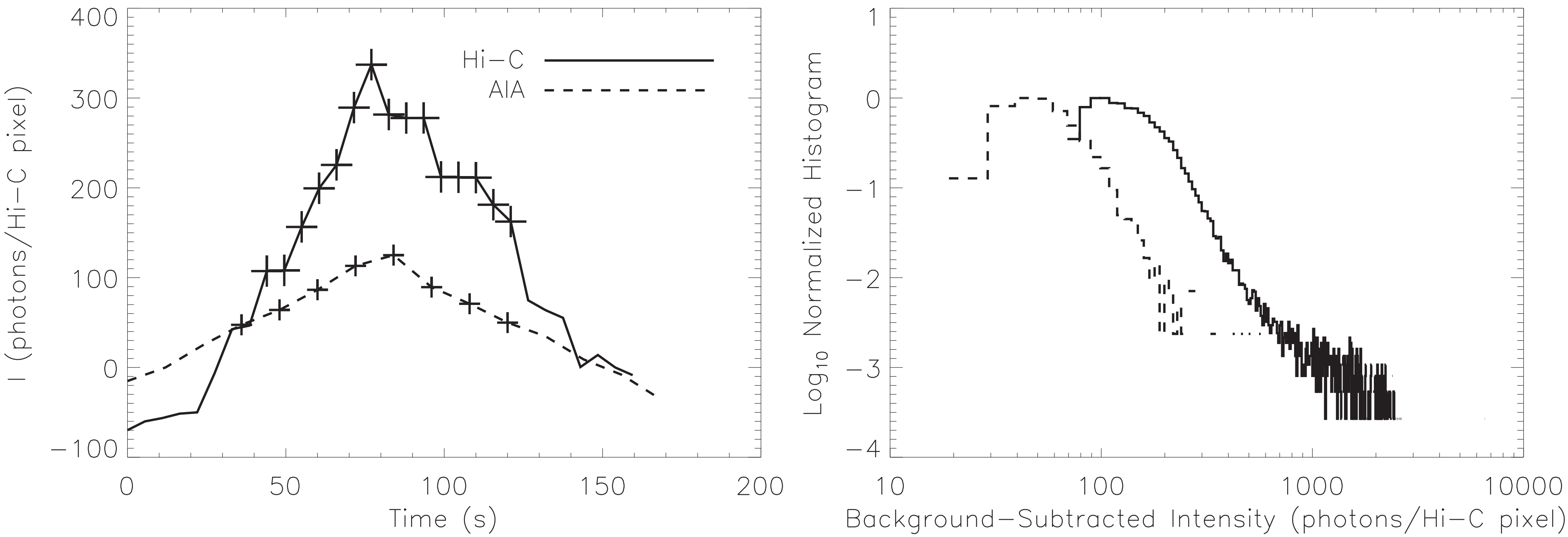


Transient Events



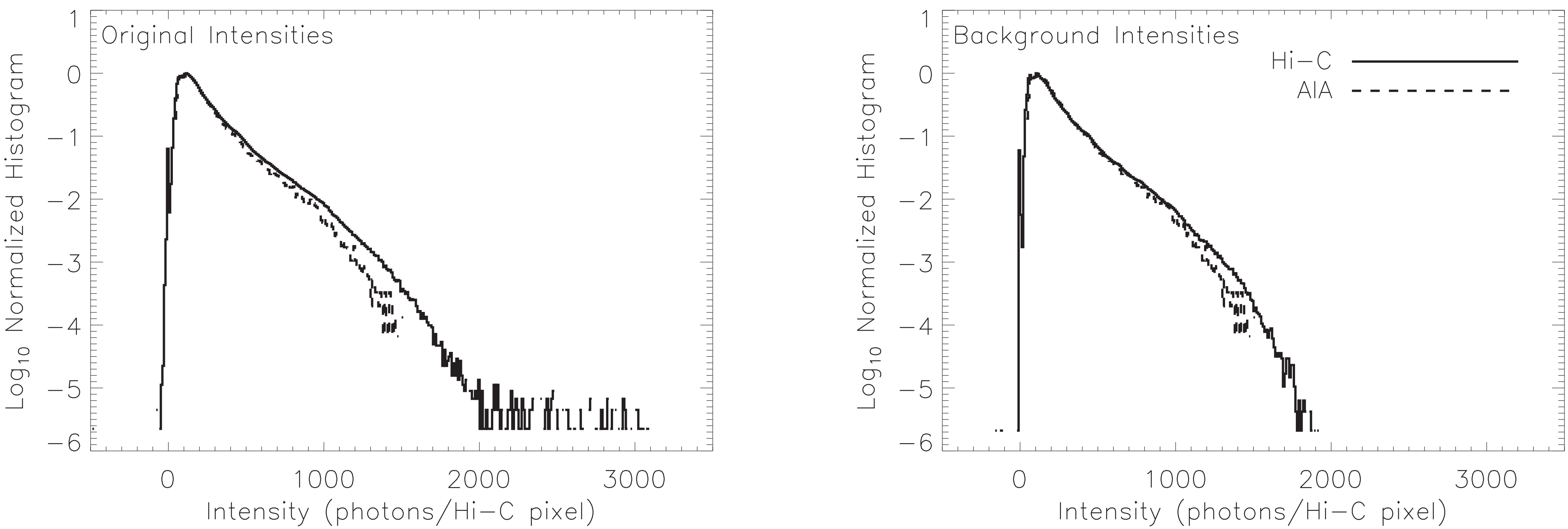
Found locations of transient events in the Hi-C and AIA data.

Transient Events



We found that transient events in Hi-C were 2.5 times brighter than transient events in AIA. We conclude this is due to linear substructure, unresolved by AIA.

Background



Hi-C reveals that the background varies smoothly, i.e., has little substructure.

Winebarger et al., 2013, in prep

Conclusions

Hi-C reveals substructure in the solar corona that is not resolved by AIA.

Hi-C reveals quickly evolving structures that cannot be observed with AIA.

Hi-C reveals that there is an intensity enhancement expected for linear substructure, but find the images are dominated by a smoothly varying background.